# Nuts and Bolts of Deploying Real Cloudproxy Applications

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## Overview

Cloudproxy is a software system that provides *authenticated* isolation, confidentiality and integrity of program code and data for programs even when these programs run on remote computers operated by powerful, and potentially malicious system administrators. Cloudproxy defends against observation or modification of program keys, program code and program data by persons (including system administrators), other programs or networking infrastructure. In the case of the cloud computing model, we would describe this as protection from co-tenants and data center insiders. To achieve this, Cloudproxy uses two components: a “Host System” (raw hardware, Virtual Machine Manager, Operating System) which provides capabilities described below to the protected program or “Hosted System” (VM, Application, Container).

This document focuses on installation and deployment tradeoffs for Cloudproxy applications. We hope these instructions allows rapid installation and configuration of Cloudproxy nodes on standard Intel Hardware with Trusted Hardware support; this requires SMX and either TPM 1.2 or TPM 2.0 support. See appendix I for a far from exhaustive list of supported hardware. We assume readers are familiar with [4] which explains Cloudproxy basic concept like measurement and principal names and eplains how to build Cloudproxy applications.

Readers can consult [1] for a fuller description. Source code for Cloudproxy as well as all the samples and documentation referenced here is in [2].

## Downloading and compiling Cloudproxy

First, you should download the Cloudproxy repository from [2]. To do this, assuming you have git repository support, type

```
git clone https://github.com/jlmucb/cloudproxy,
```

or,

```
go get https://github.com/jlmucb/cloudproxy.
```

This latter command will also install the needed go libraries. You can also download a zipped repository from github. You should probably install this in ~/src/github.com/jlmucb (which we refer to as `$CLOUDPROXYDIR`) to save go compilation problems later. It’s a good idea to put go binaries in `~/bin` as is common in Go. Follow the installation instructions in `$CLOUDPROXYDIR/Doc`; that directory also contains [1] and an up to date version of [4].

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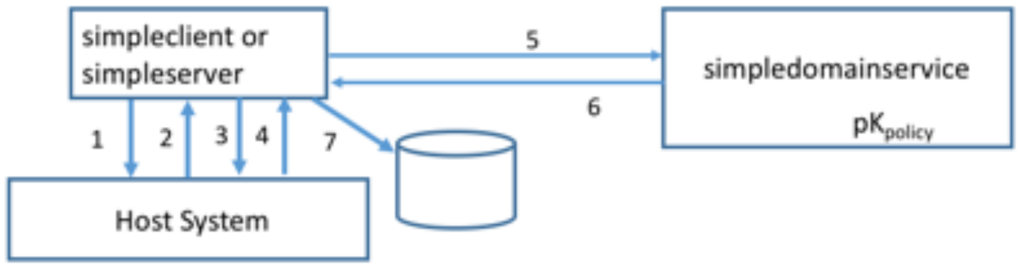
You must also install the Go development tools (and C++ development tools if you use the C++ version) as well as protobuf, gtest and gflags as described in the Go documentation.

We will continue to use the simpleexample application described in [4].

## Overview of installation on Linux

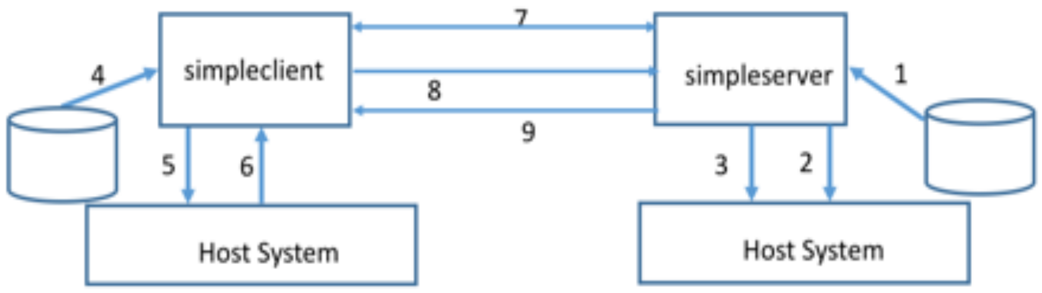
The figure below should be familiar from [4].



**Initialization**

1. simpleclient (or simpleserver) generates public/private key pair $PK_{simpleclient}$, $pK_{simpleclient}$. simpleclient requests Host System attest $PK_{simpleclient}$.
2. Host System retuns attestation
3. simpleclient generates additional symmetric keys and request Host System seal symmetric keys and $pK_{simpleclient}$.
4. Host System returns sealed blobs.
5. simpleclient connects to simpledomainservice and transmits attestation.
6. simpledomainservice returns signed Program Certificate.
7. simpleclient stores sealed blobs and Program Certificate for later activations.

**Initialization**



Operation
1. Simpleserver reads previous sealed blobs and Program Certificate.
2. Simpleserver requests Host System unseal blobs yielding symmetric keys and private program key.
3. Host system returns unsealed blobs.

4. Simpleclient reads previous sealed blobs and Program Certificate.
5. Simpleclient requests Host System unseal blobs yielding symmetric keys and private program key.
6. Host system returns unsealed blobs.

7. Simpleclient and simpleserver open encrypted, integrity protected channel using their program keys and certificates.
8. Simpleclient transmits a request to retrieve secret.
9. Simpleserver retruns secret.

**Operation**

**Overview of installing Linux**

1. Install Linux.  TPM2.0 requires a Version 4 kernel.
2. Install the Linux Kernel Development environment
3. Activate the TPM using the BIOS interface, using HW manufacturer's instructions.
4. Take ownership of the TPM and generate the appropriate keys
5. Build TBOOT
6. Configure Grub
7. Build Initramfs

**TPM 1.2 Installation**

install trousers

```
sudo agt-get install trousers
sudo agt-get install tpm-dev
sudo agt-get install tpm-tools
sudo agt-get install libtspi-dev
```

Enable and activate the TPM in BIOS and make sure TXT and vt-d is enabled too.  After enabling the TPM in BIOS, type:

```
   sudo bash
   tscd start
   tpm_takeownership -z -y
   tpm_getpubek
```

Note: If someone has already taken ownership, you must disable the tpm and reenable it.  You may have to remove power to reset the TPM and you may have to create an endorsement key using tpm_createek

You can activate the TPM from software (trousers) if you are in single user mode.  The sequence of instructions is:

```
        telinit S or boot to single user mode
        ifup lo
        start tcsd
        tpm_setpresence --assert
        tpm_setenable --enable --force
        tpm_setactive --activate --force
        reboot
```

First we must initialize the TPM physical chip with the tpm_clear command, which returns the TPM to the default state, which is unowned, disabled and inactive. That command wipes all the ownership information from the TPM, invalidates all the keys and data tied to the TPM and even disables and deactivates the TPM.

```
# tpm_clear --force
Tspi_TPM_ClearOwner failed: 0x00000007 - layer=tpm, code=0007 (7), TPM is disabled
```

We can see that the TPM is disabled, which is why we can’t clear it. This can happen if we forget to actually enable the TPM in BIOS. The first thing to do would be to actually enable the TPM in BIOS. But if the TPM has been initialized before, we would receive the output that can be seen below:

```
# tpm_clear --force
TPM Successfully Cleared.  You need to reboot to complete this operation.  After reboot
the TPM will be in the default state: unowned, disabled and inactive.
```

This would require us to reboot the computer for changes to take effect. When clearing the TPM we’ll return it to the default state, which is unowned, disabled and inactive, as already mentioned. To enable the TPM afterwards, we need the owner password. But since the TPM owner has been cleared, there is no owner password and we can set a new one without entering the old one. We can also receive an error like the following:

```
# tpm_clear --force
Tspi_TPM_ClearOwner failed: 0x0000002d - layer=tpm, code=002d (45), Bad physical
presence value
```

DO NOT SET ANY PASSWORD for the TPM.

```
# tpm_takeownership -z -y
```

If we later want to change either of the commands, we can do it with the tpm_changeownerauth command. If we pass the –owner argument to the tpm_changeownerauth command we'll be changing the administration password and if we pass the –srk into the tpm_changeownerauth command we'll be changing the SRK password. We can see the example of both commands in the output below:

```
# tpm_changeownerauth --owner
Enter owner password:
Enter new owner password:
Confirm password:

# tpm_changeownerauth --srk
Enter owner password:
Enter new SRK password:
Confirm password:
```

There are 5 keys in TPM:

TPM Endorsement Key (EK): This key is created by the manufacturer and cannot be removed. Sometimes it can be changed by the owner of the computer.
TPM Storage Key (SRK): Is the 2048 bit RSA key created when configuring the ownership. This key is stored inside the chip and can be removed. The key is used to encrypt the Storage Key (SK) and Attestation Identity Key (AIK).# tpm_setenable --enable

```
Enter owner password:
Disabled status: false

# tpm_setactive
Enter owner password:
Persistent Deactivated Status: false
Volatile Deactivated Status: false
```

There are usually two Endorsement Keys (EK): the public and private one.  The private key is always stored at the TPM and cannot even be seen by anyone,  while the public key can be displayed with the tpm_getpubek command.

```
# tpm_getpubek
Tspi_TPM_GetPubEndorsementKey failed: 0x00000008 - layer=tpm, code=0008 (8), The TPM target command has been disabled
Enter owner password:
        Public Endorsement Key:
          Version:   01010000
          Usage:     0x0002 (Unknown)
          Flags:     0x00000000 (!VOLATILE, !MIGRATABLE, !REDIRECTION)
          AuthUsage: 0x00 (Never)
```

```
Algorithm:         0x00000020 (Unknown)
Encryption Scheme: 0x00000012 (Unknown)
Signature Scheme:  0x00000010 (Unknown)
Public Key:
      a350b3a3 3edddc30 06248f4f 5d3eb80a 34fcbea0 83dde002 8dffa703 e116f8b0
      eb1962ee a65998b3 384aeb6e 85486be9 0316a6ca a189a5ba 2217b2a2 9da014db
      dfbe7731 fb675e7a 438c4775 deea54fb 0c75de5d ba961950 3eda4555 d27a9a30
      e94d39d0 a4ea314d a70eaf08 e49dd354 d57ed34d 234220d9 604471a9 86173050
      9ff9b0e5 b65cb4b5 5f46a7f9 4378bd7e 8c61b91b ad312974 fef5d70f 84f4484f
      e5c95300 0eef76f2 1667443f dc2fa82e 351d945e 6b5f75e8 828d010f 61541552
  [...]
```

## Tboot

Trousers and trousers-devel packages must already be installed in order to build lcptools.

Tboot requires an ACM Module that sets up the machine for TXT. The appropriate SINIT Module can be downloaded from http://software.intel.com/en-us/articles/intel-trusted-execution-technology/. Tboot will show the appropriate device ID in its output if it is booted with the incorrect version of sinit. Use txt-stat (installed with tboot) to read the most recent tboot logs. The current version of tboot requires version 17 or greater of the SINIT module. A copy of the module we used is in this distribution.

Building Tboot

```
cd tbootprep/tboot-1.7.0
make
make install
```

To build the LCPTools

```
cd lcptools
make
```

You may build a Launch Control Policy (LCP) which controls what can be booted. If you have no LCP, the default policy will be applied and this should work! If not, there are instructions on creating policy at the bottonm of this file. Latest tboot test was tboot-1.7.3.2 with SINIT67.BIN.

Next you must modify grub so that you can choose the tbooted linux from the boot window.

If the verified launch policy is non-empty, it is extended into PCR 17 by default. Subsequent loaded modules are extended into PCR 18 by default (Check this!). This behavior can be changed with the VLP.

The Grub(2) configuration file is usually in /boot/grub and is called grub.cfg. It is updated automatically when a kernel is updated or when you run update-grub.

Tboot module must be added as the 'kernel' in the grub.conf file.

Note that the Lenovo T410 is known not to work with the Intel IOMMU; it will not successfully boot with TBOOT.

The final grub configuration file will look something like:

```
menuentry 'Ubuntu Linux 3.0.0-16-generic with TXT' --class ubuntu --class gnu-linux --
class gnu --class os {
        recordfail
        set gfxpayload=text
        insmod gzio
        insmod part_msdos
        insmod ext2
        set root='(hd0,msdos5)'
        search --no-floppy --fs-uuid --set=root 8ab78657-8561-4fa8-af57-bff736275cc6
        echo 'Multiboot'
        multiboot /boot/tboot.gz /boot/tboot.gz logging=vga,memory,serial
        echo 'Linux'
        module   /boot/vmlinuz-3.0.0-16-generic /boot/vmlinuz-3.0.0-16-generic
root=UUID=8ab78657-8561-4fa8-af57-bff736275cc6 ro   splash vt.handoff=7 intel_iommu=on
        echo 'initrd'
        module /boot/initrd.img-3.0.0-16-generic /boot/initrd.img-3.0.0-16-generic
        echo 'sinit'
        module /boot/sinit51.bin /boot/sinit51.bin
```

Modify grub.conf to load the policy data file:

Edit grub.conf and add the following:
    module /list.data
  where you should use the path to this file.
Copy sinit into /boot and change run grub.conf then run update-grub.
Check the /boot directory to make sure tboot.gz is there.

The utility txt-stat in the utils subdirectory of tboot, can be used to view the DRTM boot log.

<u>Reported problems with TPM's</u>

The TPM, driver/char/tpm/tpm.c, depends on TPM chip to report timeout values for timeout_a, b, and d. The Atmel TPM in Dell latitude 6430u,  reports wrong timeout values (10 ms each), instead of TCG specified  (750ms, 2000ms, 750ms, 750ms for timeout_a/b/c/d respectively). You can fix the driver code and it will work.

A permissive Tboot policy is required for the non-hypervisor solutions. In this case, the system will boot whatever it finds, but it will still perform measured launch, and clients interacting with the system will still be able to check that the right software was booted by checking the PCRs. Once the hypervisor is written, a more restrictive launch control policy is possible and maybe desirable.

Put 11_tboot in /etc/grub.d

Information on PCR Usage on TPM 1.2

PCR 17 will be extended with the following values (in this order):
- The values as documented in the MLE Developers Manual
- SHA-1 hash of: tboot policy control value (4 bytes) SHA-1 hash of tboot policy (20 bytes) : where the hash of the tboot policy will be 0s if TB_POLCTL_EXTEND_PCR17 is clear

PCR 18 It will be extended with the following values (in this order):
- SHA-1 hash of tboot (as calculated by lcp_mlehash)
- SHA-1 hash of first module in grub.conf (e.g. Xen or Linux kernel)

PCR * : tboot policy may specify modules' measurements to be extended into PCRs specified in the policy
The default tboot policy will extend, in order, the SHA-1 hashes of all modules (other than 0) into PCR 19.

-------------------------------------------------------------------------------

The LCP consists of policy elements.

To specify launch policy via a list of hashes:
```
0.  sudo bash
1.  lcp_mlehash -c "command line for tboot from grub.cfg" /boot/tboot.gz > mle_hash
  - the command line in this case is the string from /boot/grub/grub.cfg
  - after multiboot tboot.gz, e.g., "logging=vga,memory,serial"
  - copy and paste:
./lcp_mlehash -c "logging=vga" /boot/tboot.gz>mle_hash
2.  lcp_crtpolelt --create --type mle --ctrl 0x00 --minver 17 --out mle.elt mle_hash
  - copy and paste
./lcp_crtpolelt --create --type mle --ctrl 0x00 --minver 17 --out mle.elt mle_hash
3.  lcp_crtpollist --create --out list_unsig.lst mle.elt pconf.elt
  - copy and paste
./lcp_crtpollist --create --out list_unsig.lst mle.elt pconf.elt
4.  lcp_crtpol2 --create --type list --pol list.pol --data list.data list_unsig.lst
  - copy and paste
./lcp_crtpol2 --create --type list --pol list.pol --data list.data list_unsig.lst
5.  cp list.pol /boot
  - copy and paste
cp owner_list.data /boot
```

Next create a verified Launch policy:
```
1.  tb_polgen/tb_polgen --create --type nonfatal vl.pol
  - copy and paste
../tb_polgen/tb_polgen --create --type nonfatal vl.pol
2.  tb_polgen/tb_polgen --add --num 0 --pcr 18 --hash image
    --cmdline "the command line from linux in grub.conf"
    --image /boot/vmlinuz-2.6.18.8
    vl.pol
  - copy and paste
../tb_polgen/tb_polgen --add --num 0 --pcr 18 --hash image --cmdline "root=UUID=cf6ae6b5-
abb5-4d5d-b823-bd798a0621de ro quiet splash $vt_handoff" --image /boot/vmlinuz-3.5.0-23-
generic vl.pol
3.  tb_polgen/tb_polgen --add --num 1 --pcr 19 --hash image
```

```
        --cmdline ""
        --image /boot/initrd-2.6.18.8
        vl.pol
      - copy and paste
    ../tb_polgen/tb_polgen --add --num 1 --pcr 19 --hash image --image /boot/initrd-3.5.0-23-
    generic vl.pol

    If any mle can be launched:
    ./lcp_crtpol2 --create --type any --pol any.pol

    Define tboot error TPM NV index:
    1.  lcptools/tpmnv_defindex -i 0x20000002 -s 8 -pv 0 -rl 0x07 -wl 0x07
        -p TPM-password
      - copy and paste
    ../lcptools/tpmnv_defindex -i 0x20000002 -s 8 -pv 0 -rl 0x07 -wl 0x07

    Define LCP and Verified Launch policy indices:
    1.  lcptools/tpmnv_defindex -i owner -s 0x36 -p TPM-owner-password
      - copy and paste
    ../lcptools/tpmnv_defindex -i owner -s 0x36 -p TPM-owner-password
    2.  lcptools/tpmnv_defindex -i 0x20000001 -s 256 -pv 0x02 -p TPM-owner-password
      - copy and paste
    ../lcptools/tpmnv_defindex -i 0x20000001 -s 256 -pv 0x02 -p TPM-owner-password

    Write LCP and Verified Launch policies to TPM:
    (modprobe tpm_tis; tcsd;)
    1.  lcptools/lcp_writepol -i owner -f [any.pol|list.pol] -p TPM-password
      - copy and paste
    ../lcp_writepol -i owner -f list.pol -p <ownerauth password>
    2.  If there is a verified launch policy:
        lcptools/lcp_writepol -i 0x20000001 -f vl.pol -p TPM-password
      - copy and paste
    ../lcptools/lcp_writepol -i 0x20000001 -f vl.pol -p TPM-password
```

Use lcp_crtpollist to sign the list:

1. openssl genrsa -out privkey.pem 2048
2. openssl rsa -pubout -in privkey.pem -out pubkey.pem
3. cp list_unsig.lst list_sig.lst
4. lcp_crtpollist --sign --pub pubkey.pem --priv privkey.pem --out list_sig.lst

Use openssl to sign the list:

1. openssl rsa -pubout -in privkey.pem -out pubkey.pem
2. cp list_unsig.lst list_sig.lst
3. lcp_crtpollist --sign --pub pubkey.pem --nosig --out list_sig.lst
4. openssl genrsa -out privkey.pem 2048
5. openssl dgst -sha1 -sign privkey.pem -out list.sig list_sig.lst
6. lcp_crtpollist --addsig --sig list.sig --out list_sig.lst

## TPM 2.0 Installation

## InitRamfs

The initial ramdisk, or initrd, is a temporary file system commonly used in the boot process of the Linux kernel. The kernel typically uses the ramdisk for making preparations before the real root file system can be mounted.

ecompress and unpack the existing initramfs

```
cd /tmp
mkdir init
cd init
cp /boot/initramfs.img-`uname -r` initrd.gz
gunzip -c -9 initrd.gz | cpio -i -d -H newc --no-absolute-filenames
```

Copy the dynamic link libraries for the executables into the filesystem

Change the initscript (init) to run dmcrypt and change the way the system disk is mounted.

```
vim init
```

Here is a simple script that works:

```
-- start simple script

#!/bin/sh

[ -d /dev ] || mkdir -m 0755 /dev
[ -d /root ] || mkdir -m 0700 /root
[ -d /sys ] || mkdir /sys
[ -d /proc ] || mkdir /proc
[ -d /tmp ] || mkdir /tmp
mkdir -p /var/lock
mount -t sysfs -o nodev,noexec,nosuid sysfs /sys
mount -t proc -o nodev,noexec,nosuid proc /proc
# Some things don't work properly without /etc/mtab.
ln -sf /proc/mounts /etc/mtab

grep -q '\<quiet\>' /proc/cmdline || echo "Loading, please wait..."

# Note that this only becomes /dev on the real filesystem if udev's scripts
# are used; which they will be, but it's worth pointing out
if ! mount -t devtmpfs -o mode=0755 udev /dev; then
        echo "W: devtmpfs not available, falling back to tmpfs for /dev"
        mount -t tmpfs -o mode=0755 udev /dev
        [ -e /dev/console ] || mknod -m 0600 /dev/console c 5 1
        [ -e /dev/null ] || mknod /dev/null c 1 3
fi
mkdir /dev/pts
```

```
mount -t devpts -o noexec,nosuid,gid=5,mode=0620 devpts /dev/pts || true
mount -t tmpfs -o "nosuid,size=20%,mode=0755" tmpfs /run
mkdir /run/initramfs
# compatibility symlink for the pre-oneiric locations
ln -s /run/initramfs /dev/.initramfs

/sbin/ifconfig lo 127.0.0.1
# can set up other networks here as needed, e.g., on eth0

# mount /boot as a place to put keys between reboots (e.g., for tcService.exe)
mkdir /boot
mount /dev/sda1 /boot

/bin/busybox sh
```

-- end simple script

- untested:
  ```
  swapoff -a
  cryptsetup [-c aes -h sha256] -s 128 -d /dev/urandom create swap /dev/sda1
  mkswap /dev/mapper/swap
  swapon /dev/mapper/swap
  ```

Put initramfs back together

```
    find . | cpio -H newc -o|gzip -9 > ../initrd.img-new
```

Copy it to the boot directory

```
  sudo cp initrd.gz /boot/initrd.img-staticLinux
```

Change /etc/grub.d to use this new initramfs.

Consult: http://manpages.ubuntu.com/manpages/karmic/man8/initramfs-tools.8.html

```
mkdir initramfs{,-old}
 cd initramfs
 gunzip -c -9 /boot/initrd.img-2.6.32-5-686 \
  | cpio -i -d -H newc --no-absolute-filenames
 find > ../initramfs.content
 cd ../initramfs-old
 gunzip -c -9 /boot/initrd.img-2.6.32-5-686.bak \
  | cpio -i -d -H newc --no-absolute-filenames
 find > ../initramfs-old.content
 cd ..
 diff -u initramfs-old.content initramfs.content
```

## Building KVM Kernel and Guest partition

Here is a quick description of how to build the kernel for host and guest.

variables: $KERNEL is the kernel source directory (e.g., /usr/src/linux-3.11.0), $CODE is the fileProxy Code directory (e.g.,~/src/fileProxy/Code)

```
    export KERNEL="/usr/src/linux-lts-quantal-3.5.0"
    export CODE="/home/jlm/fpDev/fileProxy/Code"
```

- Make sure you have all the prerequisites for building the kernel
- get the kernel source and make its root directory be $KERNEL
- navigate to ${CODE}/kvm/host-kernel
- execute the commands
  - ./apply-patches.sh $KERNEL
  - ./copy_to_kernel.sh $KERNEL

make menuconfig
   disable loadable module support
   edit config CONFIG_ACPI=n

The apply-patches.sh command might fail, depending on the vintage of the kernel you have. If the patches fail, they are fairly easy to fix by hand. You can look at the patches to see what they do:
  - the Makefile in ${KERNEL}/drivers/misc needs to have three extra lines, one obj-y += DIR for each of the three directories we added (*tcio*)
  - the Makefile in ${KERNEL}/arch/x86/kvm needs to add vmdd.o to the dependencies of kvm.o
  - ${KERNEL}/arch/x86/kvm/x86.c needs to have the lines added from the patch in ${CODE}/kvm/host-kernel/arch/x86/kvm/x86.c.patch (just acouple of lines)

- copy a working config over to $KERNEL as .config.  This is more important than it may seem at first glance.  Often dependencies in make menuconfig make getting an appropriate configuration (e.g.-one that CONFIG_INTEL_TXT=y) difficult.  A sample .config file (for Linux 3.5.7) is in config.sample in this directory. NOTE: If you're building in the VM make sure you copy a .config from a working VM kernel.
- run
  - yes "" | make oldconfig
  - yes "" | make localmodconfig
  - make (with a -j factor appropriate for your machine)

- sudo make modules_install
  - sudo make install
- and you should have a copy of the new kernel in /boot, ready to go.
- update the tboot script for this kernel and try to tboot it.

**Building and provisioning the Guest OS**

Make sure your VM has at least 20MB of disk

1. Install via virt-manager a fresh VM from a CD.
2. SSH the jlmcrypt directory into the VM.

```
apt-get install openssh-server
sudo service ssh start
sudo stop ssh
sudo start ssh
sudo restart ssh
sudo status ssh
ssh jlm@192.168.122.244
sftp
put jlmcrypt.tar .
```

3. Save the VM Image in virtmanager. You can find the IP address to SSH to by going into the VM and typing ifconfig -a.

4. Save the original libvirt xml to a safe place. For example,

```
virsh dumpxml KvmTestGuest > /home/jlm/jlmcrypt/vms/KvmTestGuestImage.xml
```

5. Copy the kernel-image file and initramfs file for the CloudProxy partition to the place you want to save them. In this example, I use /home/jlm/jlmcrypt/vms/kernel and /home/jlm/jlmcrypt/vms/initram.

6. Change the boot options for your vm (in virt-manager, for example) so that it does the direct kernel/initram boot using the files named in step 6.

7. Save the new libvirt xml to a safe place. For example,

```
virsh dumpxml KvmTestGuest > /home/jlm/jlmcrypt/vms/KvmTestGuestBoot.xml.
```

8. Copy the direct boot xml into a template file that you will reference

when you tcLaunch the VM.  For example, cp
/home/jlm/jlmcrypt/vms/KvmTestGuestBoot.xml
/home/jlm/jlmcrypt/vms/KvmTestGuestTemplate.xml

9.Edit the template file.
Replace the value of the name tag (which should have the name of vm originally) with %s.  For example,

```
<name>%s</name>
```

Replace the kernel and image tag values with %s, getting

```
<kernel>%s</kernel>
<initrd>%s</initrd>
```

Replace the disk source file value with %s, getting:

```
<disk type='file' device='disk'>
    <driver name='qemu' type='raw'/>
    <source file='%s'/>
    <target dev='hda' bus='ide'/>
    <address type='drive' controller='0' bus='0' unit='0'/>
</disk>
```

Running the newly-installed guest

```
sudo /usr/local/kvm/bin/qemu-system-x86_64 vdisk.img -m 384
```

Download and install KVM: You can use the package included in Ubuntu 7.10, just execute: apt-get install kvm You can also download the last release of KVM and compile it.

You also need the linux-headers packages for the Kernel you are using.

First of all, we need the KVM package.  You can find the actual release at http://sourceforge.net/projects/kvm/.  Download it to your server:

```
wget link/to/file /usr/src/
```

Now unpack the content.

```
cd /usr/src/
tar -xzf file.tar.gz
cd folder/to/kvm
```

Before compiling KVM make sure that your CPU supports virtualization and if that option is activated in the BIOS.  Compile KVM.

```
./configure
```

```
make
make install
```

Now load the KVM modules:
If you have an Intel CPU load:

```
modprobe kvm
modprobe kvm_intel
```

If you have an AMD CPU load:

```
modprobe kvm
modprobe kvm_amd
```

Creating the network bridge First, install bridge-utils: apt-get install bridge-utils

If you want to connect to your virtual machine later, you need to set up a network bridge. Edit /etc/network/interfaces like this (make sure to insert your public IP Address):

```
auto lo
iface lo inet loopback
auto br0
iface br0 inet static
address xxx.xxx.xxx.xxx
netmask xxx.xxx.xxx.xxx
gateway xxx.xxx.xxx.xxx
bridge_ports eth0
bridge_stp off
bridge_maxwait 5
```

Also edit /etc/qemu-ifup like this:

```
#!/bin/sh
/sbin/ifconfig $1 0.0.0.0 promisc up
/usr/sbin/brctl addif br0 $1
sleep 2
```

I recommend restarting your server at this point. If you are able to reconnect, your bridge is working.

Creating a virtual disk for a virtual machine & install a system into it. Create an .img file for installation. This file acts as a virtual disk for your vm.

**Configuring a domain**

**The role of the Domain service**

**Key management**

Key management supports the storage, distribution and critically, the rotation of symmetric content keys. In most of our programs, keys and content types (like files) are objects and have domain-wide hierarchical universal names and epochs. Epochs are monotonically increased. For example, a file used by several cloudproxy programs may contains customer information like customer names, addresses, etc. Since these are stored objects, they are encrypted and integrity protected and typically stored redundantly at several network accessible locations. The file /jlm/file/us-zone/customer-file-location1, epoch 2, type: file refers to the file with the indicated name; the epoch indicates the version of the file, different versions of the file are usually encrypted with different keys. These encryption keys also have domain-wide hierarchical universal names and epochs. Encryption keys protect other objects like keys or files. To decrypt a file, we need a chain of keys starting at the sealing key for the Cloudproxy program on a given node and terminating in the desired object (say a file). Each node of the chain consists of the name of the protector object, the protected objects and an encrypted blob consisting of the protected object encrypted (and integrity protected) by the protector key.

For example

/jlm/program-name/master-sealing-key, epoch 5, type: aes-128-gcm
/jlm/key/us-zone/customer-folder-keys, epoch 2, type: aes-128-gcm
/jlm/key/us-zone/customer-file-key, epoch 3, type: aes-128-gcm
/jlm/file/us-zone/customer-file-location1, epoch 2, type: file

Often domains will want to partition keys to provide resilience by *protection zones.* One common way to do this is to have different keys for different geographic locations. This is easily accomplished by reserving a level of the hierarchical object namespace for the zone name as is done above.

Although the foregoing name, epoch based mechanisms facilitate key rotation, it is not a complete solution. Let's first consider, given this framework, how we might rotate keys.

There are two common circumstances where new keys are introduced into a Cloudproxy environment. First, keys should be rotated regularly as part of good cryptographic hygiene and second, when programs change, their measurements change which means they can no longer access sealed data for earlier versions of the program. In both cases, similar techniques can be used to carry out the key rotation.

## Key Rotation and software upgrades

See go/support/support_libraries /protected-objects and go/support/support_libraries/ rotation_support for support routines to maintain and encrypt content keys and build chains of keys like:

Protector Object: /jlm/program-name/master-sealing-key, epoch 5, type: aes-128-gcm

Protected Object: /jlm/key/us-zone-key, epoch 2, type: aes-128-gcm
Encrypted Protected Object

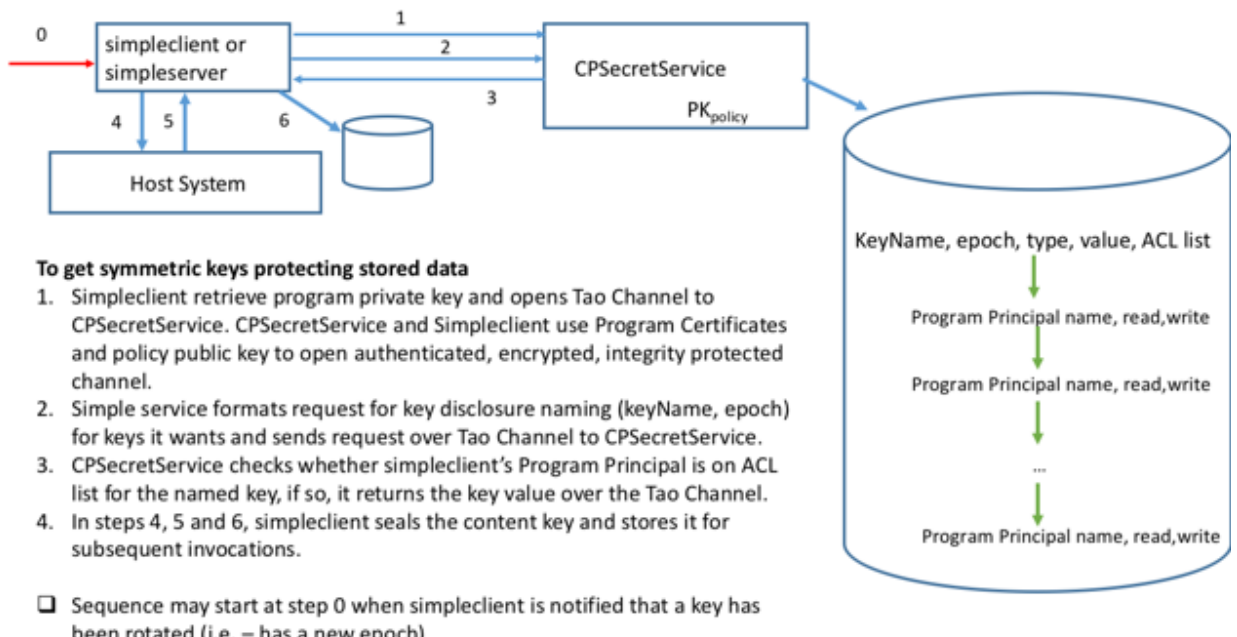
Protector Object: /jlm/key/us-zone-key, epoch 2
Protected Object: /jlm/key/us-zone-key/customer-folder-key, epoch 3, type: aes-128-gcm
Encrypted Protected Object

Protector Object: /jlm/key/us-zone-key/ customer-folder-key, epoch 3
Protected Object: /jlm/key/us-zone-key/customer-folder-key/customer-file-key, epoch 2, type: aes-128-gcm
Encrypted Protected Object

Protector Object: /jlm/key/us-zone/customer-file-key, epoch 3, type: aes-128-gcm
Protected Object: /jlm/file/us-zone/customer-file-location1, epoch 2, type: file

*Using a keystore*

A sample keystore with the required functionality is implemented in go/support/infrastructure_support/CPSecretServer. Needless to say, this program itself would likely be implemented as a cloudproxy program.


0
1
2
3
4
5
6
simpleclient or simpleserver
CPSecretService
PK policy
Host System
KeyName, epoch, type, value, ACL list
Program Principal name, read,write
Program Principal name, read,write
...
Program Principal name, read,write

**To get symmetric keys protecting stored data**

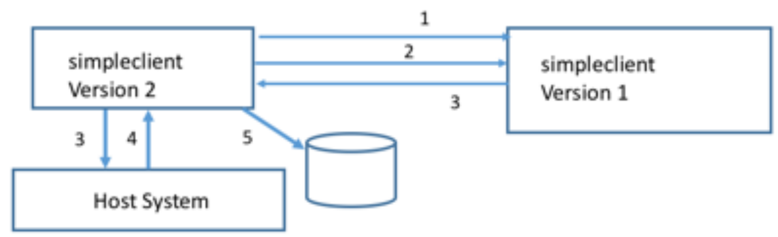
1. Simpleclient retrieve program private key and opens Tao Channel to CPSecretService. CPSecretService and Simpleclient use Program Certificates and policy public key to open authenticated, encrypted, integrity protected channel.
2. Simple service formats request for key disclosure naming (keyName, epoch) for keys it wants and sends request over Tao Channel to CPSecretService.
3. CPSecretService checks whether simpleclient's Program Principal is on ACL list for the named key, if so, it returns the key value over the Tao Channel.
4. In steps 4, 5 and 6, simpleclient seals the content key and stores it for subsequent invocations.

❑ Sequence may start at step 0 when simpleclient is notified that a key has been rotated (i.e. – has a new epoch)

**Getting content keys**

Since keys can be fetched anytime after startup and no pre-existing state is required (except for the Program key), key rotation is easy and is focused at the Secret Service. The secret service can also publish alerts when new keys are available. Upgrade when program versions change is also easy. The new version of the program just gets keys from the server. The server is updated with new ACLs as new program versions become available.

*Using policy key disclosure*



**To get symmetric keys protecting stored data from another program or version**

1. Simpleclient, version 2 retrieves program private key and opens Tao Channel to Simpleclient, version 2. Simpleclient, version 2 and Simpleclient, version 1 use Program Certificates and policy public key to open authenticated, encrypted, integrity protected channel.
2. Simple service formats request for key disclosure naming (keyName, epoch) for keys it wants and sends request over Tao Channel to CPSecretService accompanied with policy-key signed certificate stating policykey says ProgramPrincipalName (simpleclient, version 2) can read /jlm/zone-us/customer-folder-key, epoch 2.
3. Simpleclient, version 1 transmits keys over tao channel.
4. 4, 5, 6, Simpleclient, version 2 seals retrieved key for subsequent use.

**Getting content keys**

See go/support/support_libraries/secret_disclosure_support for sample code to construct and verify a policy-key signed secret-disclosure statement.

Policy-key says PrincipalName can-read /jlm/key/us-zone/customer-folder-key, epoch 2

### Installing and configuring a Cloudproxy supported KVM instance

### Installing and configuring a Cloudproxy supported TPM hosted Linux

### Installing and configuring a Linux stacked on KVM

### Preparing initramfs

Decompress and unpack the existing initramfs

```
cd /tmp
mkdir init
cd init
cp /boot/initramfs.img-`uname -r` initrd.gz
gunzip -c -9 initrd.gz | cpio -i -d -H newc --no-absolute-filenames
```

Copy the dynamic link libraries for the executables into the filesystem

```
for i in `ldd /home/jlm/jlmcrypt/fileServer.exe | cut -d' ' -f3 | sed 's/^\s*//g' | egrep -v
'^\s*$'`; do
    source=$i
    dir=`dirname $i`
    mkdir -p $dir
    dest=`echo $i | sed 's?^/??g'`
    echo "Copying $source to $dest"
    cp $source $dest
done
```

Copy the runtime directory into the filesystem, and get ifconfig, too

```
    mkdir -p home/jlm/jlmcrypt
    cp -r /home/jlm/jlmcrypt/* home/jlm/jlmcrypt/
    cp /sbin/ifconfig sbin/ifconfig
```

You might want to clean out some of the unnecessary files here.

Change the initscript (init) to run dmcrypt and change the way the system disk is mounted.

```
  vim init
```

Here is a simple script that works:

-- start simple script

```
#!/bin/sh

[ -d /dev ] || mkdir -m 0755 /dev
[ -d /root ] || mkdir -m 0700 /root
[ -d /sys ] || mkdir /sys
[ -d /proc ] || mkdir /proc
[ -d /tmp ] || mkdir /tmp
mkdir -p /var/lock
mount -t sysfs -o nodev,noexec,nosuid sysfs /sys
mount -t proc -o nodev,noexec,nosuid proc /proc
# Some things don't work properly without /etc/mtab.
ln -sf /proc/mounts /etc/mtab
```

```
grep -q '\<quiet\>' /proc/cmdline || echo "Loading, please wait..."

# Note that this only becomes /dev on the real filesystem if udev's scripts
# are used; which they will be, but it's worth pointing out
if ! mount -t devtmpfs -o mode=0755 udev /dev; then
        echo "W: devtmpfs not available, falling back to tmpfs for /dev"
        mount -t tmpfs -o mode=0755 udev /dev
        [ -e /dev/console ] || mknod -m 0600 /dev/console c 5 1
        [ -e /dev/null ] || mknod /dev/null c 1 3
fi
mkdir /dev/pts
mount -t devpts -o noexec,nosuid,gid=5,mode=0620 devpts /dev/pts || true
mount -t tmpfs -o "nosuid,size=20%,mode=0755" tmpfs /run
mkdir /run/initramfs
# compatibility symlink for the pre-oneiric locations
ln -s /run/initramfs /dev/.initramfs

/sbin/ifconfig lo 127.0.0.1
# can set up other networks here as needed, e.g., on eth0

# mount /boot as a place to put keys between reboots (e.g., for tcService.exe)
mkdir /boot
mount /dev/sda1 /boot

/bin/busybox sh

-- end simple script
```

- untested:
```
    swapoff -a
    cryptsetup [-c aes -h sha256] -s 128 -d /dev/urandom create swap /dev/sda1
    mkswap /dev/mapper/swap
    swapon /dev/mapper/swap
```

Put initramfs back together
```
      find . | cpio -H newc -o|gzip -9 > ../initrd.img-new
```

Copy it to the boot directory
```
  sudo cp initrd.gz /boot/initrd.img-staticLinux
```

Change /etc/grub.d to use this new initramfs.

Booting with initramfs: how to configure the kernel

To configure Linux to boot by mounting an initramfs image internally, set the following items on the kernel config:

```
 CONFIG_BLK_DEV_INITRD=y
 CONFIG_INITRAMFS_SOURCE=<Initramfs cpio image path>
```

After making these changes to the settings, re-compile the kernel. Finally, the kernel can be booted as follows (for instance, we report a boot on a mb442 by using a "vmlinux" with the above settings enabled):

```
host% st40load_gdb -t stmc:mb442:st40 -c sh4tp -b vmlinux mem=64m
```

No other parameters have to be passed to st40load_gdb to boot with initramfs, as the kernel mounts that image automatically.

initramfs: how to create a rootfs image

To boot Linux by using the initramfs image, create a typical ext2 (or ext3) filesystem structure in which the only difference with respect to the standard ext2/3 root filesystem used in SysV, or busybox, is related to the init file.

Usually, the init file is placed under /sbin (for both SysV and Busybox). In the initramfs rootfs image, the init file has to be placed under the root, /, as the kernel tries to execute /init instead of /sbin/init in case the initramfs image was mounted after boot.
A typical initramfs filesystem structure is as follows:

```
target% ls
bin  dev  etc  home  include  init  lib mnt  proc  sys  sbin  tmp  usr  var
```

The tool mkshinitramfs has been created to improve the process of initramfs rootfs image creation. The current version of the tool is 1.0. To get information about the tool's parameters, type the following command line:

```
      host# ./mkshinitramfs -h
      mkshinitramfs-1.0,
      usage: mkshinitramfs [-h|-H   Help]
```

```
        mkshinitramfs [-o|O:  <Initramfs CPIO image with switch option
to HDD(/dev/sda1)>]
        mkshinitramfs [-s|S:  <Initramfs CPIO image with shell on
Initramfs>]
        mkshinitramfs [-p|P:  <target rootfs path> | default:
/opt/STM/STLinux-2.3/devkit/sh4/target/]
        mkshinitramfs [-k|K:  <SH kernel version>  | default:
2.6.23_stm23_0121]
        mkshinitramfs [-b|B:  <used board> | default: mb442 (STi710x
based board)]
```

mkshinitramfs must be executed as "root" on the host machine in which a full target root filesystem has previously been installed. It is configured to use default parameters, as listed in the output from the -h option. To change any of the parameters, apply the command line options listed in the help.

The tool mkshinitramfs creates a short initramfs. If invoked with the -s option, the generated initramfs is the final rootfs. If invoked with the -o option, the generated initramfs is a temporary rootfs to be switched to the real one on the HDD.

The script mkshinitramfs internally defines some variables that are useful when defining which files, libraries, scripts and tools are to be placed on the initramfs image.
The variables are:

```
$DIRS
$BINFILES
$SBINFILES
$ETCFILES1
$USRBINFILES
```

Version 1.0 of the mkshinitramfs tool can be downloaded from mkshinitramfs tool as a compressed tar.gz file.

If the initramfs rootfs is created to be used temporarily before switching to the real target rootfs on a hard disk drive, a setup script is needed, which is then passed to the chroot in order to setup the final real rootfs properly. This script loads the user space services needed at runtime, such as klogd, udev, D-Bus, and so forth.

If the -o option is used, mkshinitramfs generates a CPIO image in which the following command line is inserted after the kernel mounts the initramfs:

```
mount /dev/sda1 /mnt
chroot /mnt /etc/init.d/rcS-initramfs
```

## Installing and configuring Docker containers

## Scale and deployment considerations

## Just write your applications properly:  simple, right?

## Oops: What to do if there’s a gigantic breach

## Planned features

Local state rollback support, a few more crypto algs

## Out of town, call collect

## Acknowledgements

## References

**[1] Manferdelli, Roeder, Schneider, The CloudProxy Tao for Trusted Computing,** http://www.eecs.berkeley.edu/Pubs/TechRpts/2013/EECS-2013-135.pdf.
**[2] CloudProxy Source code,** http://github.com/jlmucb/cloudproxy. Kevin Walsh and Tom Roeder were principal authors of the Go version.
**[3] TCG, TPM specs,** http://www.trustedcomputinggroup.org/resources/tpm_library_specification
**[4] Beekman, Manferdelli, Wagner,** Attestation Transparency: Building secure Internet services for legacy clients**.** AsiaCCS, 2016.
**[5]** Manferdelli, CloudProxy Nuts and Bolts.
[6] Intel, The MLE Development Guide

## Supported Hardware

## Dmcrypt

fdisk to make partitions (/dev/sda)
mkfs.ext2  to make file system
change to single user mode
grub-install root-directory=/dev/sda
CRYPTDISKS_ENABLE=Yes in /etc/defaults/cryptdisks

/etc/crypttab
swap /dev/hda1 /dev/urandom swap
/etc/fstab
/dev/swapper/swap none
swap sw,pri=1 0 0

For swap:

swapoff -a
cryptsetup [-c aes -h sha256] -s 128 -d /dev/urandom create swap /dev/sda1
mkswap /dev/mapper/swap
swapon /dev/mapper/swap

Shell script prototype

```
#
#   For debian, first do the following:
#
#   Change to single user mode
#       cat /proc/swaps   (to find out swap device)
#       /sbin/runlevel    (to find runlevel)
#       /sbin/telinit 1   (to go single user)
#       ctrl-alt-f7 puts Linux into console mode.
#
#   /etc/defaults/cryptdisks
#       CRYPTDISKS_ENABLE=Yes
#   /etc/crypttab
#       swap /dev/sda5 /dev/urandom swap
#   /etc/fstab
#       /dev/mapper/swap none
#       swap sw,pri=1 0 0
#   /etc/crypttab
#       swap /dev/sda5 /dev/urandom cipher=aes-cbc-essiv:sha256,size=256,hash=sha256,swap
#   /etc/fstab
#       /dev/mapper/cryptoswap none swap sw 0 0
#
#   /dev/sda5 is swap device
#
# Ref: The whole disk Nov, 2006, Linux-magazine.com, Michael Nerb
#
swapoff -a
cryptsetup -c aes -h sha256 -s 128 -d /dev/urandom create swap /dev/sda5
mkswap /dev/mapper/swap
swapon /dev/mapper/swap
```

```
#
# To remove:
#   swapoff /dev/mapper/swap
#   cryptsetup [luks] remove swap
```

## Grub

## Initram script

```
mkdir initramfs{,-old}
 cd initramfs
 gunzip -c -9 /boot/initrd.img-2.6.32-5-686 \
  | cpio -i -d -H newc --no-absolute-filenames
 find > ../initramfs.content
 cd ../initramfs-old
 gunzip -c -9 /boot/initrd.img-2.6.32-5-686.bak \
  | cpio -i -d -H newc --no-absolute-filenames
 find > ../initramfs-old.content
 cd ..
 diff -u initramfs-old.content initramfs.content
```

A sample init that dynamically loads the driver (don't do this) is:

1 Decompress initrd into localdirectory
2 Copy needed drivers in /drvs directory
3 Copy fileProxy/fileClient/tcService binaries in /bin directory and required libraries in lib and lib64 directories
4 Copied keys to /bin/HWRoot directory
5 Replaced init with my custom init
6 Loaded tcioDD
7 Configured Ethernet
8 Script does not boot all services
9 Package initramfs.igz
10 Copy to /boot
11 Modify entry for OS Tboot section in grub.cfg. replaced initrd by initramfs.igz
12 Reboot machine
13 From cmd line type : /bin/tcService.exe –directory /bin/ &
14 tcService connected to keynegoServer on different machine.

```
#---start
#!/bin/sh
echo "Test CloudProxy minimal boot environment!"

[ -d /dev ] || mkdir -m 0755 /dev
[ -d /root ] || mkdir -m 0700 /root
[ -d /sys ] || mkdir /sys
[ -d /proc ] || mkdir /proc
[ -d /tmp ] || mkdir /tmp
```

```
mkdir -p /proc/net/dev
mkdir -p /var/lock

mount -t sysfs -o nodev,noexec,nosuid sysfs /sys

# Function for dropping to a shell
shell () {

        /bin/busybox sh
}

# Basic /dev content, we need it as fast as possible.
mount -t tmpfs dev /dev
mount -t proc proc /proc

test -c /dev/null || mknod /dev/null c 1 3
test -c /dev//tty || mknod /dev/tty c 5 0
test -c /dev/urandom || mknod /dev/urandom c 1 9
test -c /dev/random || mknod /dev/random c 1 8
test -c /dev/zero || mknod /dev/zero c 1 5
test -c /dev/tpm0 || mknod /dev/tpm0 c 10 224
test -c /dev/tcioDD0 || mknod /dev/tcioDD0 c 100 0

#insmod /drvs/tpm_tis.ko
insmod /drvs/tcioDD.ko

echo "loaded tcioDD drivers..."

insmod /drvs/e1000e.ko

/sbin/ifconfig eth0 192.168.241.11
/sbin/route add default gw 192.168.241.10

/bin/busybox sh

# Clean up.
umount /proc
umount /sys
```

```
# Not booting to the real thing at this time.

#---end
```

Standard initramfs init file:

```
#!/bin/sh

[ -d /dev ] || mkdir -m 0755 /dev
[ -d /root ] || mkdir -m 0700 /root
[ -d /sys ] || mkdir /sys
[ -d /proc ] || mkdir /proc
[ -d /tmp ] || mkdir /tmp
mkdir -p /var/lock
mount -t sysfs -o nodev,noexec,nosuid sysfs /sys
mount -t proc -o nodev,noexec,nosuid proc /proc
# Some things don't work properly without /etc/mtab.
ln -sf /proc/mounts /etc/mtab

grep -q '\<quiet\>' /proc/cmdline || echo "Loading, please wait..."

# Note that this only becomes /dev on the real filesystem if udev's scripts
# are used; which they will be, but it's worth pointing out
if ! mount -t devtmpfs -o mode=0755 udev /dev; then
        echo "W: devtmpfs not available, falling back to tmpfs for /dev"
        mount -t tmpfs -o mode=0755 udev /dev
        [ -e /dev/console ] || mknod -m 0600 /dev/console c 5 1
        [ -e /dev/null ] || mknod /dev/null c 1 3
fi
mkdir /dev/pts
mount -t devpts -o noexec,nosuid,gid=5,mode=0620 devpts /dev/pts || true
mount -t tmpfs -o "nosuid,size=20%,mode=0755" tmpfs /run
mkdir /run/initramfs
# compatibility symlink for the pre-oneiric locations
ln -s /run/initramfs /dev/.initramfs

# Export the dpkg architecture
export DPKG_ARCH=
. /conf/arch.conf
```

```
# Set modprobe env
export MODPROBE_OPTIONS="-qb"

# Export relevant variables
export ROOT=
export ROOTDELAY=
export ROOTFLAGS=
export ROOTFSTYPE=
export IP=
export BOOT=
export BOOTIF=
export UBIMTD=
export break=
export init=/sbin/init
export quiet=n
export readonly=y
export rootmnt=/root
export debug=
export panic=
export blacklist=
export resume=
export resume_offset=
export recovery=

# mdadm needs hostname to be set. This has to be done before the udev rules are
called!
if [ -f "/etc/hostname" ]; then
	/bin/hostname -b -F /etc/hostname 2>&1 1>/dev/null
fi

# Bring in the main config
. /conf/initramfs.conf
for conf in conf/conf.d/*; do
	[ -f ${conf} ] && . ${conf}
done
. /scripts/functions

# Parse command line options
for x in $(cat /proc/cmdline); do
	case $x in
```

```
init=*)
        init=${x#init=}
        ;;
root=*)
        ROOT=${x#root=}
        case $ROOT in
        LABEL=*)
                ROOT="${ROOT#LABEL=}"

                # support any / in LABEL= path (escape to \x2f)
                case "${ROOT}" in
                */*)
                if command -v sed >/dev/null 2>&1; then
                        ROOT="$(echo ${ROOT} | sed 's,/,\\x2f,g')"
                else
                        if [ "${ROOT}" != "${ROOT#/}" ]; then
                                ROOT="\x2f${ROOT#/}"
                        fi
                        if [ "${ROOT}" != "${ROOT%/}" ]; then
                                ROOT="${ROOT%/}\x2f"
                        fi
                        IFS='/'
                        newroot=
                        for s in $ROOT; do
                                newroot="${newroot:+${newroot}\\x2f}${s}"
                        done
                        unset IFS
                        ROOT="${newroot}"
                fi
                esac
                ROOT="/dev/disk/by-label/${ROOT}"
                ;;
        UUID=*)
                ROOT="/dev/disk/by-uuid/${ROOT#UUID=}"
                ;;
        /dev/nfs)
                [ -z "${BOOT}" ] && BOOT=nfs
                ;;
        esac
        ;;
```

```
rootflags=*)
        ROOTFLAGS="-o ${x#rootflags=}"
        ;;
rootfstype=*)
        ROOTFSTYPE="${x#rootfstype=}"
        ;;
rootdelay=*)
        ROOTDELAY="${x#rootdelay=}"
        case ${ROOTDELAY} in
        *[![:digit:].]*)
                ROOTDELAY=
                ;;
        esac
        ;;
resumedelay=*)
        RESUMEDELAY="${x#resumedelay=}"
        ;;
loop=*)
        LOOP="${x#loop=}"
        ;;
loopflags=*)
        LOOPFLAGS="-o ${x#loopflags=}"
        ;;
loopfstype=*)
        LOOPFSTYPE="${x#loopfstype=}"
        ;;
cryptopts=*)
        cryptopts="${x#cryptopts=}"
        ;;
nfsroot=*)
        NFSROOT="${x#nfsroot=}"
        ;;
netboot=*)
        NETBOOT="${x#netboot=}"
        ;;
ip=*)
        IP="${x#ip=}"
        ;;
boot=*)
        BOOT=${x#boot=}
```

```
          ;;
ubi.mtd=*)
          UBIMTD=${x#ubi.mtd=}
          ;;
resume=*)
          RESUME="${x#resume=}"
          ;;
resume_offset=*)
          resume_offset="${x#resume_offset=}"
          ;;
noresume)
          noresume=y
          ;;
panic=*)
          panic="${x#panic=}"
          case ${panic} in
          *[![:digit:].]*)
                    panic=
                    ;;
          esac
          ;;
quiet)
          quiet=y
          ;;
ro)
          readonly=y
          ;;
rw)
          readonly=n
          ;;
debug)
          debug=y
          quiet=n
          exec >/run/initramfs/initramfs.debug 2>&1
          set -x
          ;;
debug=*)
          debug=y
          quiet=n
          set -x
```

```
                ;;
        break=*)
                break=${x#break=}
                ;;
        break)
                break=premount
                ;;
        blacklist=*)
                blacklist=${x#blacklist=}
                ;;
        netconsole=*)
                netconsole=${x#netconsole=}
                ;;
        BOOTIF=*)
                BOOTIF=${x#BOOTIF=}
                ;;
        hwaddr=*)
                BOOTIF=${x#BOOTIF=}
                ;;
        recovery)
                recovery=y
                ;;
        esac
done

if [ -n "${noresume}" ]; then
        export noresume
        unset resume
else
        resume=${RESUME:-}
fi

maybe_break top

# export BOOT variable value for compcache,
# so we know if we run from casper
export BOOT

# Don't do log messages here to avoid confusing graphical boots
run_scripts /scripts/init-top
```

```
maybe_break modules
[ "$quiet" != "y" ] && log_begin_msg "Loading essential drivers"
load_modules
[ "$quiet" != "y" ] && log_end_msg

[ -n "${netconsole}" ] && modprobe netconsole netconsole="${netconsole}"

maybe_break premount
[ "$quiet" != "y" ] && log_begin_msg "Running /scripts/init-premount"
run_scripts /scripts/init-premount
[ "$quiet" != "y" ] && log_end_msg

maybe_break mount
log_begin_msg "Mounting root file system"
. /scripts/${BOOT}
parse_numeric ${ROOT}
maybe_break mountroot
mountroot
log_end_msg

maybe_break bottom
[ "$quiet" != "y" ] && log_begin_msg "Running /scripts/init-bottom"
run_scripts /scripts/init-bottom
[ "$quiet" != "y" ] && log_end_msg

# Preserve information on old systems without /run on the rootfs
if [ -d ${rootmnt}/run ]; then
	mount -n -o move /run ${rootmnt}/run
else
	# The initramfs udev database must be migrated:
	if [ -d /run/udev ] && [ ! -d /dev/.udev ]; then
		mv /run/udev /dev/.udev
	fi
	# The initramfs debug info must be migrated:
	if [ -d /run/initramfs ] && [ ! -d /dev/.initramfs ]; then
		mv /run/initramfs /dev/.initramfs
	fi
	umount /run
fi
```

```
# Move virtual filesystems over to the real filesystem
mount -n -o move /sys ${rootmnt}/sys
mount -n -o move /proc ${rootmnt}/proc

validate_init() {
	checktarget="${1}"

	# Work around absolute symlinks
	if [ -d "${rootmnt}" ] && [ -h "${rootmnt}${checktarget}" ]; then
		case $(readlink "${rootmnt}${checktarget}") in /*)
			checktarget="$(chroot ${rootmnt} readlink ${checktarget})"
			;;
		esac
	fi

	# Make sure the specified init can be executed
	if [ ! -x "${rootmnt}${checktarget}" ]; then
		return 1
	fi

	# Upstart uses /etc/init as configuration directory :-/
	if [ -d "${rootmnt}${checktarget}" ]; then
		return 1
	fi
}

# Check init bootarg
if [ -n "${init}" ]; then
	if ! validate_init "$init"; then
		echo "Target filesystem doesn't have requested ${init}."
		init=
	fi
fi

# Common case: /sbin/init is present
if [ ! -x "${rootmnt}/sbin/init" ]; then
	# ... if it's not available search for valid init
	if [ -z "${init}" ] ; then
		for inittest in /sbin/init /etc/init /bin/init /bin/sh; do
```

```
				if validate_init "${inittest}"; then
					init="$inittest"
					break
				fi
			done
		fi

		# No init on rootmount
		if ! validate_init "${init}" ; then
			panic "No init found. Try passing init= bootarg."
		fi
fi

maybe_break init

# don't leak too much of env - some init(8) don't clear it
# (keep init, rootmnt)
unset debug
unset MODPROBE_OPTIONS
unset DPKG_ARCH
unset ROOTFLAGS
unset ROOTFSTYPE
unset ROOTDELAY
unset ROOT
unset IP
unset BOOT
unset BOOTIF
unset UBIMTD
unset blacklist
unset break
unset noresume
unset panic
unset quiet
unset readonly
unset resume
unset resume_offset

# Chain to real filesystem
exec run-init ${rootmnt} ${init} "$@" ${recovery:+--startup-event=recovery}
<${rootmnt}/dev/console >${rootmnt}/dev/console 2>&1
```

```
panic "Could not execute run-init."
```

Wrong:

```
    gunzip initrd.gz
    cpio -iv < initrd
```

From http://reboot.pro/topic/14547-linux-load-your-root-partition-to-ram-and-boot-it/

his tutorial will guide you through the steps to modify your initramfs to load all files from / to a tmpfs. This will only work with Debian 5 or newer and Ubuntu 9 ? or any unix thats supports booting from a initramfs. Since this is a virtual filesystem in RAM, not a virtual harddisk, this has many advantages.

What you need:
* lots of RAM
* Debian based distribution or any that supports booting from initramfs
* mkinitramfs or a tool to build a new initramfs
* some linux knowledge
* no need to create an image
* no need for Grub4Dos
* no need for a "special driver"

Step 1:
Choose a distribution thats supports booting from initramfs. (like ubuntu)

Step 2:
Install to harddisk. Make sure you split it into multiple partitions (/, /boot, /home, swap, ...).

Step 3:
Boot your new system, install updates, drivers if neccessary (this will improve performance), strip it down to the minimum. Every file will be loaded to RAM ! A fresh install uses about 2 GB auf harddisk-space.

Step 4:
modify /etc/fstab :
* make a backup
cp /etc/fstab /etc/fstab.bak* find the line specifing the root partition and change it in:

none / tmpfs defaults 0 0* save

Step 5:
edit the local script in your initramfs:
cd /usr/share/initramfs-tools/scripts/* make a backup of /usr/share/initramfs-tools/scripts/local
cp local local.bak* modify local, find this line:
# FIXME This has no error checking

# Mount root

mount ${roflag} -t ${FSTYPE} ${ROOTFLAGS} ${ROOT} ${rootmnt}* change it to:
# FIXME This has no error checking

# Mount root

#mount ${roflag} -t ${FSTYPE} ${ROOTFLAGS} ${ROOT} ${rootmnt}

mkdir /ramboottmp

mount ${roflag} -t ${FSTYPE} ${ROOTFLAGS} ${ROOT} /ramboottmp

mount -t tmpfs -o size=100% none ${rootmnt}

cd ${rootmnt}

cp -rfa /ramboottmp/* ${rootmnt}

umount /ramboottmp
* save
* execute, or rebuild initramfs
mkinitramfs -o /boot/initrd.img-ramboot* replace modified local with original file
cp -f local.bak localStep 6:
* modify this file (needs a better solution)
/boot/grub/grub.cfg* copy the first boot entry and replace the /initrd line with this:
/initrd /initrd.img-ramdisk* label the new entrie as RAMBOOT
This will boot our generated initramfs instead the original one.
Step 7:
* reboot
* choose standart boot (no ramdisk)

* choose RAMBOOT and all your files on the root partition will be loaded to a tmpf

You have 2 possibilities for creating such a file. Allocate the disk space needed by the .img file directly. In this case the file will have a  size of 4 GBytes.

```
dd if=/dev/zero of=disk01.img bs=1G count=4
```

Create an .img file with a maximal size but the disk space will only be  allocated when needed.  In this case, the maximum size will be 10 GBytes,  but the disk space used will be the space required by the files in the vm.

```
qemu-img create -f qcow2 disk01.img 10G
```

Next, we need an ISO file of the system you want to install. Make sure you  have downloaded on onto your server.

Let's install the virtual machine. When you don't have physical access to  the server, start the installation with the VNC option. So you can connect to  the VNC session and you will have the GUI from the installer. In this case we  will set the RAM size of the vm to 512 MBytes.  At the moment the vm doesn't  have access to the network interface. I prefer activating it later,  after configuring IP Addresses of the vm.

```
kvm -hda disk01.img -cdrom os.iso -m 512 -boot d -vnc IP:1
```

Now you can connect to IP:1 with a VNC client. You can configure your system  and network settings at this point. Don't forget to install a SSH Server. After configuring, shut down the vm.

Now we are going to start the vm with networking support. We assign a  MAC-Address to the vm network interfaces. This is important if you use  more than 1 vm. Every vm will get its MAC-Address.

```
kvm -hda disk01.img -m 512 -boot c -net nic,vlan=0,macaddr=00:16:3e:00:00:01
-net tap -nographic -daemonize
```

After some seconds you should be able to connect via ssh to the vm.  If not, you can add the -vnc option to check if there are problems.

I had the problem that I couldn't reach my vm over the network after some time.  I had to add a different network card emulation to the start command. This solved my problem.

```
kvm -hda disk01.img -m 512 -boot c -net
nic,vlan=0,macaddr=00:16:3e:00:00:01,model=rtl8139 -net tap -nographic -
daemonize
```

If you have the problem that your configured network interface isn't starting, delete  the following file (depending on your os):

```
/etc/udev/rules.d/70-persistent-net.rules
or
/etc/udev/rules.d/z25-persistent-net.rules
```

You also have the possibility to add more virtual disks to one vm. You can add  the following parameter to the start command:

```
-hdb disk02.img
```

You can add more virtual machines if you need so. You could also create start scripts for your vms.